



CHICAGO JOURNALS



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Source: *Publications of the Astronomical Society of the Pacific*, Vol. 125, No. 925 (March 2013), pp. 225–226

Published by: [The University of Chicago Press](#) on behalf of the [Astronomical Society of the Pacific](#)

Stable URL: <http://www.jstor.org/stable/10.1086/669931>

Accessed: 09/05/2013 10:34

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## Obituary

### Wallace L. W. Sargent (1935–2012)

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*Received 2013 January 10; accepted 2013 January 14; published 2013 February 12*

By any measure, Professor Wallace L. W. Sargent (known to colleagues and friends as “Wal”) was one of the most influential and consistently productive astronomers of the last 50 years; he authored or coauthored more than 320 refereed journal articles, which have received more than 25,000 citations. He never rested on past laurels—65 of his papers (with >5000 citations) have appeared since the year 2000. Wal remained active as a teacher and researcher until just weeks before the end of his life (he officially retired from the Caltech faculty on 2012 October 1). His impact on the field of astrophysics was remarkably broad as well as seminal; among many other awards, he was elected in 1981 as a Fellow of the Royal Society (U.K.) and as a member of the National Academy of Sciences in 2005, his first year of eligibility after becoming a naturalized U.S. citizen.

Many who know Wal will also be aware that his personal history was no less remarkable—he was born into a distinctly working-class family (his father was a gardener and his mother a house cleaner) in central Lincolnshire (UK) just before the start of the second World War. To provide an idea as to how unlikely his path has been, he was the very first student from the Scunthorpe Technical High School to attend university of any kind. Wal studied at the University of Manchester for both his undergraduate degree (1956) and his PhD (1959). Upon receiving his PhD, Wal moved to California to become a Research Fellow at Caltech, working with Jesse Greenstein. Aside from 2 years as a Senior Research Fellow at the Royal Greenwich Observatory (a most important time in retrospect, since that is where he met his wife and fellow astronomer Anneila; they were married in 1964), Wal spent all of his 45 year career in California, first as a junior faculty member in Physics at UC San Diego (1964–1966), after which he moved to Caltech (1966) where he spent the rest of his career on the faculty. In 1981 he became the Ira S. Bowen Professor of Astronomy.

Perhaps the most impressive aspect of Wal Sargent’s contributions to astrophysics is the range of subjects in which he made fundamental contributions. Among them are the first measurement of the primordial abundance of helium from observations of metal-poor galaxies (with Leonard Searle), the first dynamical evidence for the presence of super-massive black holes at the centers of galaxies (with Peter Young), the measurement of the mass of the Galaxy using the radial velocities of outer satellites (showing that it supported the developing view that the

mass distribution in galaxies is very extended and isotropic; with F.D.A. Hartwick), the discovery that most nearby galaxies harbor low-luminosity nuclear activity (with Alex Filippenko and Luis Ho), and inferences concerning the mechanism generating the luminosity of quasars and Seyfert galaxies (e.g., with Matt Malkan).

If there is an area of astrophysics in which Wal’s accomplishments were greatest, it is the study of the diffuse intergalactic medium and the chemical history of the universe—a field he pioneered in the 1960s and of which he remained in the forefront through his entire career. Beginning soon after the discovery of the cosmological nature of quasars, Wal took an immediate interest in analyzing their spectra as a means to learn about the distribution, physical state, and cosmic evolution of diffuse gas comprising the general medium outside of galaxies. Initially, the quality of the information was limited by the technology of the time, particularly the detectors—photographic emulsions. Beginning in the early- to mid-1970s, Wal began an extremely fruitful collaboration with Alec Boksenberg (then at University College, London), who had developed a two-dimensional photon counting detector system (called the IPCS) which allowed for spectroscopy of relatively faint objects with up to 20 times higher throughput than photography, along with zero detector noise. The IPCS coupled with the Palomar 200-inch telescope made it possible to obtain quasar spectra of unprecedented quality. This capability allowed Sargent, Boksenberg, and colleagues to revolutionize the field over the ensuing decade, with a spectacular series of papers that not only presented exciting new data, but also introduced many of the statistical techniques and scientific interpretation that have remained the standard ever since. Wal’s 1980 paper (with Peter Young, Alec Boksenberg, and David Tytler) on the intergalactic nature of the Lyman  $\alpha$  forest firmly established that these lines represented intergalactic neutral hydrogen using sophisticated statistical methods, many of which were new to astrophysics. It was a huge paper, both in terms of its influence, and physically—it could have been 10 separate papers, given its content. Subsequent papers established the first evidence for cosmological evolution of the intergalactic medium, and evidence connecting absorption systems containing detected heavy elements with intervening galaxies (at redshifts that were then far beyond where galaxies were being observed directly)

Through the mid 1980s to early 1990s, Sargent and colleagues collected larger samples of QSO absorption line systems in order to improve constraints on the evolutionary behavior of the IGM over time, as well as to establish the connection with galaxies; these surveys were ambitious enough to remain relevant some 15–20 years after publication.

During the years 1984–1993, Wal spent a huge portion of his time on the development of the Keck Observatory as a co-chair of the Keck Science Steering Committee, a group of scientists that oversaw nearly every aspect of the project, from scientific capabilities to the design of the support facilities. It is impossible to overstate the importance of this group, and of Wal's leadership of it, during the ~10 year period between inception and first light—they were largely responsible for the immediate scientific success of Keck. The Keck telescope and HIRES spectrometer, both of which saw first light in 1993, opened up an entirely new era in the study of the intergalactic medium, thanks to the routine ability to obtain high resolution, high signal-to-noise ratio spectra of a large numbers of quasars. The combination of the quantum leap in the information content of the spectra, and concurrent advances in the theoretical understanding of diffuse baryonic material (increasingly seen as a medium which accurately traces the filaments of dark matter on all scales), led to new insights into the chemistry and physical evolution of the IGM. Sargent and colleagues led many, if not most, of the developments on the observational side—measuring abundances and abundance ratios in so-called “damped Lyman  $\alpha$ ” systems, sites of large columns of neutral H believed to be associated with distant galaxies along the line of sight, characterization of the chemistry of the diffuse IGM far from galaxies, and most recently, extending the IGM observations to the highest redshifts, close to the epoch ( $z > 6$ ) when the medium is believed to have been reionized by a combination of quasars and young galaxies. These investigations helped open up entirely new fields, such as the study of “Population III” stars, which may have imprinted a “metallicity floor” on the entire diffuse IGM, and theoretical study of the mechanisms for moving heavy elements from the sites of their creation into low-density regions of the universe. The Lyman  $\alpha$  forest has now become a primary tool for cosmology because of its apparently-faithful tracing of the dark matter distribution on scales where other techniques break down.

Wal was justifiably proud of his cohort of graduate students over the course of his career—there was a total of 18 students according to Wal's web page devoted to the subject, which he introduced with the following: “All of my Ph.D. students are listed below. Remarkably, like me, they almost all showed a reluctance to work for a living and instead found jobs in academia.” In addition to his personal achievements, his track record with his graduate students was exceptional—most of the 18 went on to distinguished academic careers in a startling variety of scientific areas. To name a few, along with their most recent institutions and general areas of study: A. Filippenko (UC

Berkeley; supernovae and supernova cosmology), Edwin Turner (Princeton; exoplanets), Patrick Osmer, Matthew Malkan (respectively, Ohio State and UCLA; quasars and active galaxies), John Huchra and Steve Kent (respectively, Harvard-Smithsonian CfA, U. Chicago/Fermilab; stellar populations and surveys of the local universe), John Kormendy (U. of Texas; galaxy structure and dynamics), Robert O'Connell and Daniel Kunth (respectively, U. of Virginia, Institut d'Astrophysique de Paris; UV and X-ray astronomy), and Peter Young (Caltech, deceased 1981), Rob Simcoe (MIT), and George Becker (IoA Cambridge), all working on quasar absorption line studies of the distant universe.

I confess that I am also a Sargent “product”—I was lucky enough to work with Wal at Caltech over the years 1984–1989, during which time I was his only graduate student. Wal (with tongue in cheek) always called me “Team”—a name I am sure will sound familiar to some of his other former students. Any conversation we had could then be called a “Team meeting”, which Wal enjoyed as an ironic tweak of groups that were actually large enough to need such things. I remember my first meeting with Wal (nearly 30 years ago) in his office in Robinson Hall, during the first few weeks of the academic year—I was terrified and intimidated and was not at all sure I had a right to be there. Quickly I learned that I had nothing to fear—Wal turned out to be funny, irreverent, and extremely interested in discussing many subjects both within and outside of astronomy. Our conversations would almost always end up on a topic other than my thesis—some of Wal's favorites were baseball, music, Manchester United, books, and sumo wrestling. Wal had an uncanny ability to inject humor into any situation that was in danger of becoming overly serious, quite necessary for calming a neurotic young graduate student such as myself. A favorite game of Wal's was where he would pretend to be ignorant of all American popular culture and ask me naive questions about it (since I was apparently his only direct link to all things American, despite his decades spent in southern California). Looking back on my formative years as a Caltech graduate student, it is hard to recall ever receiving direct advice from Wal, and yet somehow he profoundly influenced the way I view science. In my personal view, the principal characteristics that Wal passed on to his students are a taste for interesting problems, a healthy degree of skepticism and self-criticism, and an attitude that celebrates the unexpected turns and tangents that often arise when one “looks to see what is out there.”

As a colleague, Wal has been just as important to me as he had been as a mentor. Although we had not worked together directly on science since I returned to Caltech 17 years ago, I realize how much I would look forward to Wal's regular visits to my office for informal conversations and catching up on “gossip” (of which Wal was a big fan). In all honesty, such times spent with Wal have been essential to my sanity and well-being. I am not quite sure how I will cope without our “Team meetings.” I will miss Wal for much more than his scientific accomplishments—he was a close friend.